Evaluation of the work quality of the sugar beet planter in relation to the sugar beet seed parameters

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Abstract: Due to the restructuring of the Slovak agriculture managed by the Common agricultural policy of the European union, the acreage under sugar beet has been significantly reduced (32 000 ha in 2003, 27 700 ha in 2006). For the growers with a high intensity of growing, sugar beet has the potential to bring profit. The quality of the crop stand establishment during seeding is considered as the basis for a high yield of the sugar beet roots. Biological and technological properties of sugar beet seed, tillage quality and the quality of the seed placement into the soil have a dominant effect on the value and evenness of the sugar beet field emergence. A regular seed placement is also required as the precondition for minimising the harvest losses. During seeding, the distance between two successive seeds in the row depends upon the technical parameters of the planter – forward speed, type of the seeding unit mounting to the frame, the design and the type of the seeding mechanism drive. Our paper is focused on the comparison of the seeding quality of two types of sugar beet planters equipped with different seeding mechanisms: ground driven seeding mechanism and electric motor driven seeding mechanism. Unicorn synchro drive planter provided better results (x_2 = 17.89 mm) than Meca 2000 planter (x_2 = 28.44 mm). The planters were evaluated in experiments conducted in field conditions according to the International standard ISO 7256/1.

Keywords: sugar beet; seeding quality; exact seeding

The main function of the sugar beet planter is to provide optimal seed placing in vertical and horizontal levels with minimal sugar beet seed damage. The required placement of the sugar beet seeds in horizontal level can be characterised by a regular seed placement in the row. Besides the above mentioned factors, the quality of the seed placement is given by technical parameters of the sugar beet planter:

– type of seeding unit mounting to the planter frame;
– specification of the seeding unit (type of seeder opener, final speed of the seed at the outlet from the seeding disc);
– acceleration of the seeding unit in vertical direction;
– forward ground speed of the sugar beet planter, etc.

The main aim of the field experiments was to compare two different systems of the drive of the mechanical seeding mechanism with the internal filling of the seeding openings. The evenness of the placement of seeds in horizontal line was considered as the evaluative criterion. The effect of the seeding unit on the seeding quality and sugar beet roots was studied by Páltik *et al.* (1994), Burema *et al.* (1980), Mesi (2000), Bajkin *et al.* (2005), Rybář (2005) and Findura and Páltik (2006).

MATERIAL AND METHODS

During the field experiments, we compared sugar beet planters using the same system of the filling of gathering holes, but with different seeding mechanisms: ground driven seeding mechanism, and electromotor driven seeding mechanism (Figure 1). The experiments were conducted in field conditions according to the International standard ISO 7256/1 Sowing equipment – Test methods. Part 1: Single seeds drills (precision drills). With regard to the above standard, the following characteristics were determined: soil conditions, seed size and shape. The specifications of the sugar beet planters tested are given in Table 1. The range of planter forward speed varied from 0.65 to 2.5 m/s.

Both sugar beet planters were equipped with a disc seeding mechanism with internally filled gathering cells (Figure 2). From the seed hopper the seeds are transported to the seeding chamber, one side wall

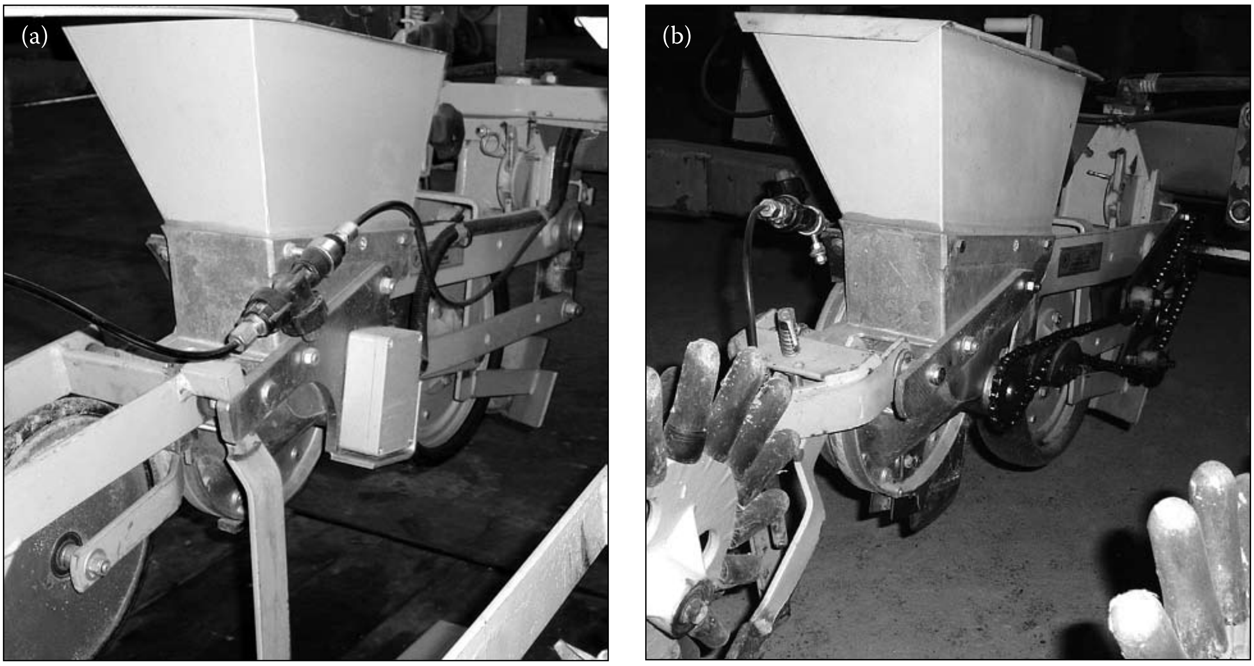

Figure 1. (a) seeding mechanism driven by 12 V electromotor; (b) ground driven seeding mechanism with chain drive

of which is formed by a vertical seeding disc. The seeds are pressed by their own weight to the wall of the seeding disc and they enter one-by-one the leading slot formed in front of the gathering hole. The dropping of the seeds through calibrated holes in the radial direction is supported by centrifugal force.

The accurate seeding and regular spacing of sugar beet seeds in the row are affected also by the seed trajectory after leaving the seeding mechanism. To the group of factors affecting the spacing of the seeds and, consequently, also the spacing of the sugar beet plants belong the interrelationship between the horizontal component of the seeding disc horizontal velocity v_{px} and the planter forward speed v_p. This interrelationship was the subject of the field experiments (Figure 3 and Figure 4).

When evaluating the horizontal placement of sugar beet seeds (and later also sugar beet plants) in horizontal direction, the measured distances b_{ri} were classified into the following groups:

multiples, when b_{ri} matches the condition:

$0 \leq b_{ri} < 0.5$ (EPS) – number of n_0 (1)

placement within required spacings

0.5 (EPS) $\leq b_{ri} < 1.5$ (EPS) – number of n_1 (2)

single misses

1.5 (EPS) $\leq b_{ri} < 2.5$ (EPS) – number of n_2 (3)

double misses

2.5 (EPS) $\leq b_{ri} < 3.5$ (EPS) – number of n_3 (4)

(k – 1) – multiple misses

$(k - 1) \times$ (EPS) $\leq b_{ri} < (k + 0.5) \times$ (EPS) – number of n_k (5)

where:

EPS – effective plant spacing, which is equal to the mean distance between the plants without regard to the multiples and misses (Findura & Páltik 2006)

The accuracy of the plants placement can be expressed by the standard deviation of the plant distances (s_p) from the effective plant spacing

Table 1. Specifications of the sugar beet planters

Type of planter	Seed outlet height (mm)	Seeding disc diameter (mm)	Number of gathering holes (Ø hole, mm)	Type of hitching of the seeding unit to the frame	Seeding depth kontrol	Seeding depth (mm)	Type of seeding opener
Meca 2000	61	252	5 (5)	parallelogram	depth wheel	0–55	tine
Unicorn synchro drive	65	228	5 (5)	paralelogram	depth wheel	0–60	tine

(a) (b)

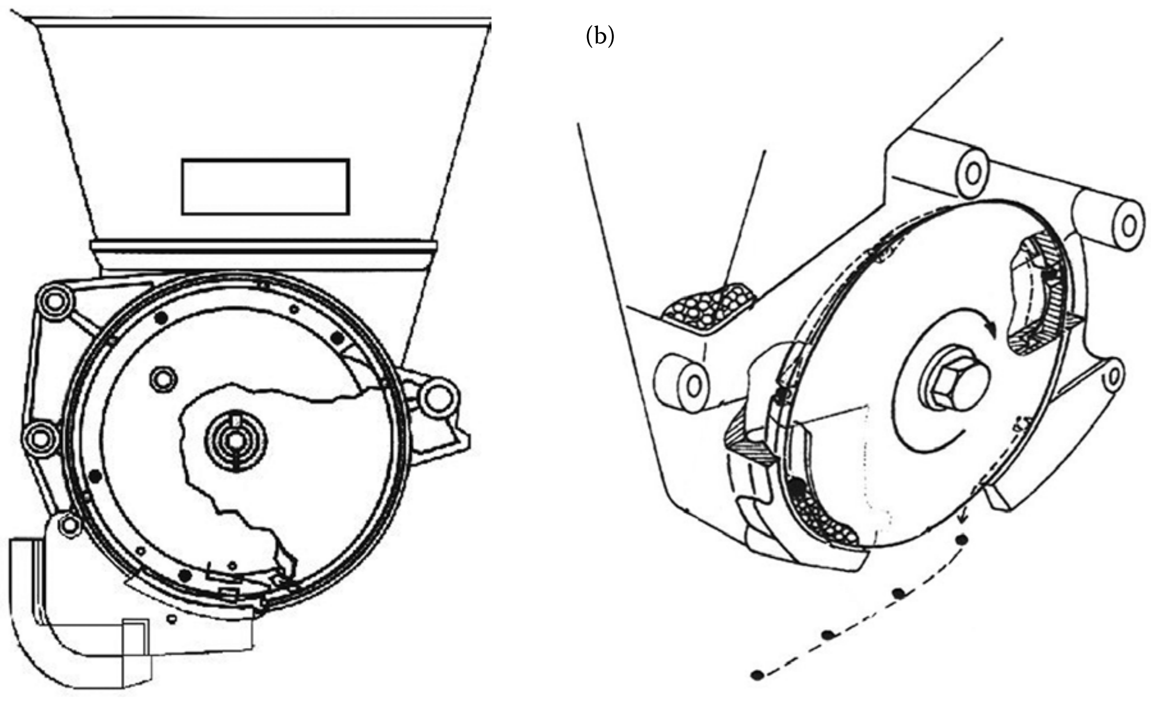

Figure 2. Functional charts of sugar beet planters compared; (a) Unicorn synchro drive planter, (b) Meca 2000 planter

$$s_r = \sqrt{\sum_{k=0}^{i}[b_{ri} - k(EPS)]^2} \quad (6)$$

where:
EPS – effective plant spacing
b_{ri} – distance measured between the plants in the row

RESULTS AND DISCUSSION

The results obtained will be presented in the following order:
- characterising of the size and shape parameters of the sugar beet seeds which have been used in the experiments,
- characterising and evaluation of the seed velocity conditions within the seeding mechanism,
- evaluation of the placement of the seeds in horizontal line.

Size and shape parameters of the sugar beet seeds used in experiments

Mechanical seeding mechanism with the internal filling of the gathering holes (Table 1) requires coated seeds to match the quality requirements. The seeds should have the ball-type shape with the calibration 3.25–4.75 mm. The size and shape parameters of the seeds are given in Table 2.

Due to the voluntary agreement between the sugar beet seed manufacturers, the seed calibration of 3.5–4.75 mm has been introduced in the market. The tolerated share of the seeds under 3.5 mm and above 4.75 mm is 6%.

With respect to the mean dimensions of the seeds (length, width, and thickness), we can observe that the seed variety Triplex, when compared to the seed variety Liana, has a more typical shape. As a weakness of the seed variety Triplex, we can consider a

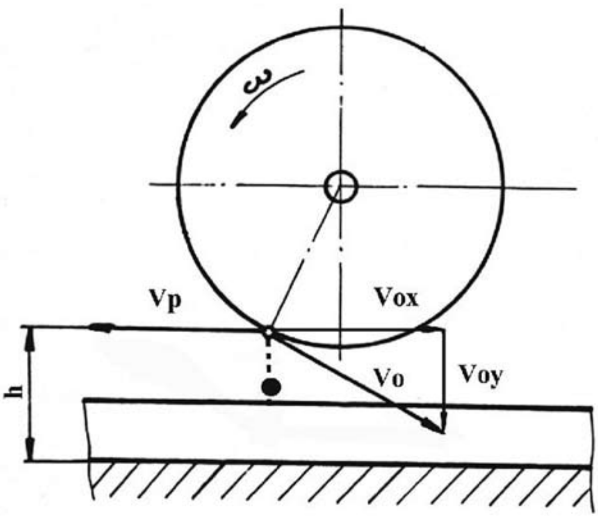

Figure 3. Velocity conditions of the motion of the sugar beet seed falling with free fall in relation to the soil surface

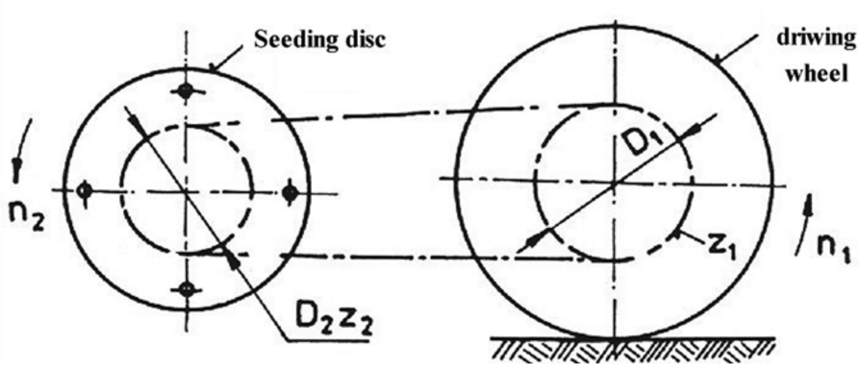

Figure 4. The factors affecting the seeding disc peripheral velocity of the ground driven seeding mechanism

higher share of the seeds in the undercalibration size group (percentage share of the seeds with the thickness smaller than 3.5 mm). On the other side, there were no seeds with the width surpassing the upper calibration range of 4.75 mm.

According to the results obtained, we can state the following:

- of the seeds compared, the seed variety Liana matched the criterion of the international agreement of the sugar beet seed manufacturers regarding the seed calibration,
- when evaluating the shares of the seeds in different size groups, it was found out that the seed variety Triplex had the highest share of the undersized seeds (Table 3).

Evaluation of the seed velocity for the given seeding mechanism

In order to eliminate generating of the seeds after falling to the seeding slot in the soil we require that the planter forward speed and the horizontal component of the seeding disc peripheral velocity should be equal. In such case, the seed in relation to the soil surface will fall by free-fall and its generating after falling to the seeding slot will be theoretically equal

Table 2. Size and shape characteristics of the seeds used in the experiments

Variety (calibration) (mm)	Germination (%)	Average seed size parameters: lenght $\overline{l}$ (mm)	width $\overline{s}$ (mm)	thickness $\overline{h}$ (mm)	Shape coefficients: $k_1 = \frac{\frac{l+s}{2}}{h}$	$k_2 = \frac{s}{h}$	$k_3 = \frac{l}{h}$	$k_4 = \frac{l}{s}$	Weight of 1 000 seeds (g)
Liana (3.5–4.75)	97	4.03	3.78	3.56	1.097	1.068	1.132	1.066	26.80
Triplex (3.5–4.75)	98	3.81	3.61	3.43	1.083	1.055	1.111	1.053	28.36

$\overline{l}, \overline{s}, \overline{h}$ – mean lenght, width and thickness of the seeds; k_1, k_2, k_3, k_4 – shape coefficients of the seeds; seed variety Triplex – the seed sown by Unicorn synchro drive planter, seed variety Liana – the seed sown by Meca 2000 planter

Table 3. Percentage of the sugar beet seeds in different size groups with calibration of 3.5–4.75 mm (according to the unofficial agreement of the sugar beet seed manufacturers)

Seed width (mm)		Required size limit (%)		Triplex (%)		Liana (%)	
3.5–4.75		88		80.67		95.25	
< 3.5		6		19.33		4.75	
3.25–3.49	< 3.25	4.5	1.5	16.66	2.67	3.75	1
> 4.75		6		0		0	
4.75–4.99	> 4.99	4.5	1.5	0	0	0	0

Table 4. Selected parameters of the compared planters for sugar beet seeding

Type of planter	Seeding spacing (m)		0.140	0.160	0.180	0.197	0.200
	required rpm of the seeding disc n_v (s^{-1}) for v_p=1 m/s, v_p=2.5 m/s	v_{p1}	1.43	1.25	1.11	1.02	1.00
		v_{p2}	3.58	3.13	2.78	2.54	2.50
Meca 2000	peripheral velocity of the seeding disc v_o (m/s)	v_{o1}	1.13	0.99	0.88	0.81	0.79
		v_{o2}	2.83	2.47	2.20	2.01	1.98
	difference between seeding disc peripheral velocity and forward speed (v_p–v_o)	v_{p1}	0.13	0.01	0.12	0.19	0.21
		v_{p2}	0.33	0.03	0.30	0.49	0.52
Unicorn synchro drive	peripheral velocity of the seeding disc v_o (m/s)	v_{o1}	1.02	0.90	0.80	0.73	0.72
		v_{o2}	2.57	2.24	1.99	1.82	1.79
	difference between seeding disc peripheral velocity and forward speed (v_p–v_o)	v_{p1}	0.02	0.10	0.20	0.27	0.28
		v_{p2}	0.07	0.26	0.51	0.68	0.71

Meca 2000 planter: number of gathering cells – 5 and seeding disc diameter – 0.252 m

Unicorn synchro drive planter: number of gathering cells – 5 and seeding disc diameter – 0.228 m

to zero. A high peripheral speed of the seeding disc in both seeding mechanisms creates a prerequisite for matching the above given requirements for a high planter forward speed. The higher is the difference between both speeds, the higher is the possibility of seeds spreading during seeding. Such inaccuracies can be enlarged by an inaccurate function of the seeding disc driving mechanism (slippage of the planter ground driven wheel, play in the chain drive, etc.).

On the basis of the results obtained it can be stated that the lowest difference between the seeding disc peripheral velocity and the forward speed was found out with the planter Unicorn synchro drive when the seed spacing was 140 mm (Table 4). For the planter Meca 2000, the most suitable velocity

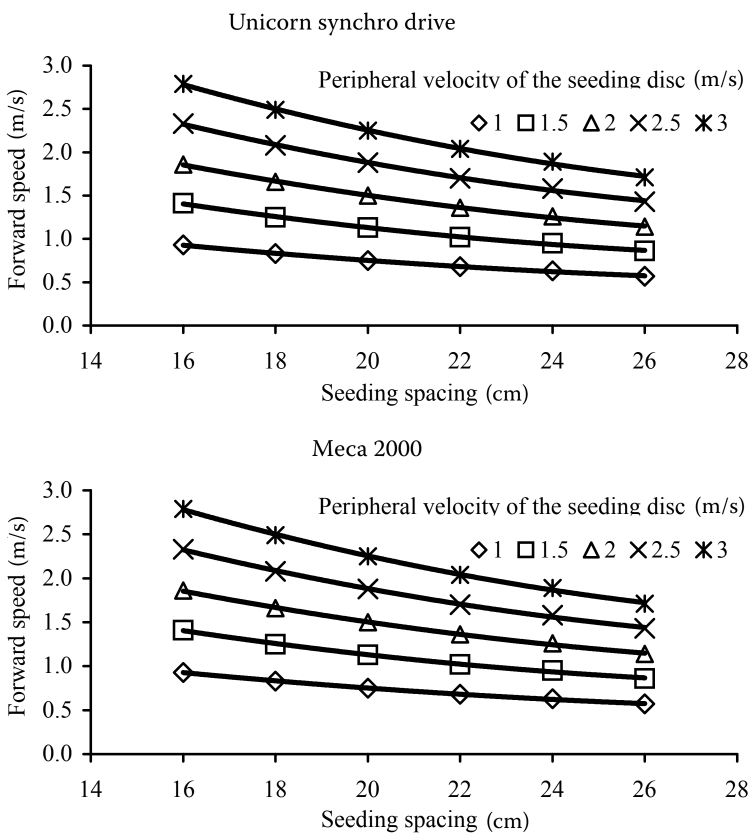

Figure 5. Effect of seed spacing on forward speed for different values of seeding disc peripheral velocity

Table 5. Results of the horizontal placement of the plants sown by Meca 2000 planter and Unicorn synchro drive planter

Seed variety (calibration) (mm)	Type of planter	Forward speed (m/s)	Required (adjusted) plant spacing (mm)	Effective plant spacing EPS x_1 (mm)	Field emergency: Relative emergency(%)	Field emergency: Numer of plants per ha (1000/ha)	Standard deviation of the plant spacing x_2 (mm)	Placement of the plants (%): Required placement of plants (PRR)	Double multiples x_3	Single misses x_4	Double misses	> more than double misses
Liana (3.5–4.75)	Meca 2000	0.65	197	191.5	77.76	86.8	33.25	68.6	3.1	21.0	4.2	3.1
		1.04	197	192.4	72.33	83.5	31.69	67.5	2.4	20.8	6.3	3.0
		1.65	197	192.9	68.11	78.5	28.91	63.8	2.2	20.7	7.5	5.8
		1.93	197	190.3	69.97	81.7	28.81	65.2	2.4	19.2	6.5	6.8
		2.35	197	193.6	62.68	71.9	28.44	56.4	3.1	20.8	10.8	8.8
Triplex (3.5–4.75)	Unicorn synchro	0.83	160	153.4	75.16	108.849	23.15	73.29	0.93	21.12	2.48	2.17
		1.11	160	132.3	81.44	136.836	20.66	81.44	0	12.89	3.35	2.32
		1.67	160	135.2	85.79	140.997	17.89	85.79	0	8.01	4.13	2.07
		2.50	160	158.1	78.97	110.990	30.13	78.98	0	13.07	0.57	7.39

x_1 – effective plant spacing (EPS) is the mean plant spacing when multiples and misses are not considered; x_2 – statistic parameter characterising variability of the plant spacing around the value of effective plant spacing (ISO 7256/1); x_3 – doubles, when plant spacing is less than 0.5 EPS; x_4 – single misses, when plant spacing is higher than 1.5 and less than 2.5 EPS, etc.

ratio was observed at the seed spacing 160 mm in row (Figure 5).

Evaluation of the horizontal seed placement

Horizontal seed placement can be characterised as a space arrangement of the seeds given by the variability of the seed spacing in the rows (*b*) for the inter-row distance (*a* = 450 mm). It is considered as a seeding quality indicator. As the measurement of the distances between seeds directly after the seeding is very complicated, we carried out such a measurement only when the plants emerged. We made the comparison of the quality of the seeds and plants distribution in horizontal level according to the ISO Standard 7256/1. We measured the distances between plants and the following parameters were calculated:

– effective plant spacing (EPS),
– standard deviation of the distances between plants from the effective plant spacing,
– percentage of the multiples (presence of two or more plants, where there should have been only one) and single-, double-, and repeated misses.

The standard deviation of the plant spacing was used as a tool allowing to evaluate the placement of the seeds and plants in horizontal level and the variability of the seeding process. It gives the information about the accuracy of the seeding. Small values of the standard deviation of the plant spacing mean that the planter sows the seeds with regular spacing which means higher accuracy. From the results obtained follows that better results were reached with the planter Unicorn synchro drive (x_2 = 17.89 mm), not only from the point of accuracy of the seed placement, but also from the point of multiples, and single- and repeated misses. This fact can be explained by more suitable velocity conditions, which affects the resulting trajectory of the seed when it leaves the outlet of the seeding disc. The results are also confirmed by the values of the required placement of plants (RPP), when mean value of RPP for Unicorn synchro drive planter was 79.87%, while that for Meca 2000 planter was only 64.3%.

CONCLUSION

During the field experiments, we compared sugar beet planters using the same system of filling of gathering holes, but with different seeding mechanisms: ground driven seeding mechanism and electromotor driven seeding mechanism. It can be stated that, in the range of higher forward speed, both planters reached better results from the point of the required placement of plants in the row. This is given by the design of the seeding mechanism. In the area of the seeding quality, better results were obtained with Unicorn synchro drive planter with more suitable velocity conditions, elimination of inaccuracies caused by losses in transmission and slippage of driving wheel of the seeding mechanism.

From the results obtained, we can see that better results were obtained with the planter Unicorn synchro drive (x_2 = 17.89 mm and required placement of plants was 79.87%), not only from the point of accuracy of the seed placement, but also from the point of multiples, and of single- and repeated misses. With the planter Meca 2000 the obtained value x_2 was 28.44 mm and the required placement of plants was 64.3%.

The seeding disc of the Unicorn synchro drive planter is powered by an electromotor which allows to disconnect the drive for the given seeding units but also densification of the seeding in rows adjoining the tramlines. All this can be considered as advantages for the expansion of the planter in practice.

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Abstrakt

Findura P., Nozdrovický L., Tóth P. (2008): **Hodnotenie kvality práce sejačiek pre sejbu cukrovej repy vo vzťahu k vybraným vlastnostiam osiva.** Res. Agr. Eng., **54**: 148–154.

V dôsledku reštrukturalizácie slovenského poľnohospodárstva , riadenej Spoločnou poľnohospodárskou politikou Európskej únie, došlo k výraznému zníženiu pestovateľských plôch cukrovej repy (32 000 ha v roku 2003, 27 000 ha v roku 2006). Pri vysokej intenzite pestovania je cukrová repa potenciálne zisková plodina. Základom dosahovania vysokých úrod je kvalitné založenie porastu pri sejbe. Na dosiahnutie vysokej a rovnomernej poľnej vzchádzavosti majú vplyv biologické a technické vlastnosti osiva, príprava pôdy a okrem iného aj kvalita uloženia osiva v pôde. Z pohľadu znižovania zberových strát požadujeme pravidelné rozmiestnenie rastlín v riadku. Na tieto vzdialenosti vplývajú už pri sejbe predovšetkým technické parametre sejačky ako sú pracovná rýchlosť, spôsob uchytenia výsevnej jednotky, konštrukcia a spôsob pohonu výsevného ústrojenstva a iné. Pri hodnotení kvality sejby lepšie výsledky dosiahla sejačka Unicorn synchro drive (x_2 = 17,89 mm) v porovnaní s Mecou 2000 x_2 = 28,44 mm.V príspevku porovnávame kvalitu sejby dvoch na našom trhu perspektívnych sejačiek, ktoré sme hodnotili v poľných podmienkach v zmysle normy ISO 7256/1.

Kľúčové slová: cukrová repa; kvalita sejby; presná sejba

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